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Impacts of soil amendments practices on growth and yield attributes of spring planted sugarcane under water deficit conditions

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The studies related to effect of irrigation levels and soil amendments practices on sugarcane was conducted on a loamy soil under field conditions at Agronomic/Research/Farm area, University/of Agriculture, Faisalabad/Pakistan during growing season 2016-17. The experiment was laid out in RCBD with split plot arrangement and three replications with a net plot size of 4.8 m x 10.0 m. Planting was sown in 120 cm wide trenches using two eyed cane setts in dual rows @ 75,000 setts ha^{-1} by hand placement. Sugarcane variety CPF-249 was planted on Last week of March 2016. All agronomic operations were kept uniform except (N) nitrogen and (P) phosphorus fertilizers and time of irrigations. In experiment, potash @112 kg ha'1 was applied in trenches at the time of planting while Nitrogen and phosphorus fertilizer was applied as per treatment plan from organic and inorganic sources with irrigation combinations viz. I_0T_0 = 100% of recommended Irrigation (16 Irrigations) + Control, I_0T_1 = 100% of recommended Irrigation (16 Irrigations) + Press-mud, I_0T_2 = 100% of recommended Irrigation (16 Irrigations) + Polymer Coated SSP, I_0T_3 = 100% of recommended Irrigation (16 Irrigations) 50% Cane Trash boiler ash+50% SOP, I_1T_0 = 75% of recommended Irrigation (12 Irrigations) + Control, I_1T_1 = 75% of recommended Irrigation (12 Irrigations) + Press-mud, I_1T_2 = 75% of recommended Irrigation (12 Irrigations) + Polymer Coated SSP, I_1T_3 = 75% of recommended Irrigation (12 Irrigations) + 50% Cane Trash boiler ash+50% SOP, I_2T_0 = 50% of recommended Irrigation (08 Irrigations) + Control, I_2T_1 = 50% of recommended Irrigation (08 Irrigations) + Press-mud, I_2T_2 = 50% of recommended Irrigation (08 Irrigations) + Polymer Coated SSP, I_2T_3 = 50% of recommended Irrigation (08 Irrigations) + 50% Cane Trash boiler ash+50% SOP. Effect of irrigation levels and soil amendments techniques on number of internodes and harvest index remained non-significant. The highest number of tillers m^{-2} (15.63) was recorded at I_0T_2 (100% of recommended irrigation + polymer coated SSP) and minimum m^{-2} (11) at I_1F_1 (75% of recommended irrigation + press mud). The maximum cane length (220.00 cm) was recorded at I_0T_2 (75% of recommended irrigation + polymer coated SSP), weight per stripped cane (1.09 kg) at I_0T_2 (100% of recommended irrigation + polymer coated SSP), while minimum cane length (157 cm) was recorded at I_2T_0 (50% of recommended irrigation + control), weight per stripped cane (0.51 kg). All the quality parameters Brix (%), Sucrose content in juice (%) exposed non-significant effect of irrigation levels and soil amendments techniques in spring planted sugarcane. Maximum commercial cane sugar (CCS) (15.00 %) and cane sugar recovery (14.53 %) was recorded at I_0T_2 (100% of recommended irrigation + polymer coated SSP).

INTRODUCTION

Sugarcane is a primary crop to fulfill table sugar needs of the common people due to its resourceful metabolism. In addition, sugarcane is also a bulk source of by-products such as press-mud, sucrose, liquor molasses, spent wash distillery water, cane bagasse etc (Kuasha Mahmud *et al*. 2018). The sugarcane contribution in GDP and value addition of Pakistan is 0.7% and 3.4%, respectively and nearly 1.22 million hectares are cultivated and production of cane stood at 73.6 million tones (Govt. of Pakistan, 2016-17). In Pakistan, average yield of cane is 60.4 tons ha^{-1}. Worldwide sugarcane is being cultivated in more than ninety countries under an area of more than 26.5 million hectares with a production 0f 1.88 billion tons (FAO, 2016). Sugarcane have second position in cash crops of Pakistan, after cotton (Govt. of Pakistan, 2017). Worldwide cane yield of Pakistan ranks fifth with an average yield of 57.84 tons ha^{-1} (FAO, 2106). Sugarcane raises billions of revenues in the form of duties and taxes to the government of Pakistan, being a primary source of income from agriculture (Nazir *et al.*, 2013). Every year, to produce millable canes, sugarcane demand about 64-acre inches of water. Being

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a C_4 crop, sugarcane metabolism can possibly accumulate outstanding biomass with high mineral application and different contributions to biomass amount bringing about its conspicuous stature (Botha and Moore, 2014). Water and mineral take-up are main factor in acquiring such biomass and fulfilling the metabolic needs of sugarcane when grown under marginally fertile environments and on sandy soil texture with water shortage (Edme *et al*., 2005). Pakistani growers spend high contribution on planting this 0.1 million tiller crop with a not very many ratoon cuts proving it less productive than alternate areas of the world where more number of ratoons are harvested (Kapur *et al*., 2011). Low ratoonability is one easy way to save such resources to control inefficient use of inputs including land, water, labor etc. In addition, increasing consumptive use of water keeps on being a significant challenge for the sugar business in this part of the globe where soil is made from alluvial texture with lower to moderate water holding capacity (Mahesh *et al*., 2013). Commonly, the poor agricultural practices, conventional planting techniques and improper utilization of nutrients are the major causes of low cane yield and sugar recovery. In Pakistan and over the world, the cane growing communities apart from growers to use the best management practices to maximize output. Hence, balanced nutrition results in per unit soil productivity as well as better cane yield. Sugarcane ratoon crop is highly exhaustive with respect to soil nutrition as it needs more nitrogen than planted cane because massive damage of roots and high rate of immobilization of soil nitrogen (Lal and Singh, 2008). The main cause of low sugarcane yield is a lodging which also effect the juice and sugar recovery percentage (Anwar *et al*., 2002). There are different reasons behind low sugarcane production and sucrose content e.g. Pakistan is lie outside the tropic region of the world. Two-third of the sugarcane is obtained from the northern regions including areas with periodic snow fall, minimum precipitation and high temperatures those impact cane yield and sugar recovery drastically (Nazir, 1994). As a result of persistent usage of chemicals and inorganic fertilizer in agriculture the soil has been extremely harmed (Ajay Kumar Singh and Pritee Sharma, 2018). It has eradicated to lessen soil micro-biota useful for making unavailable nutrients to available form hence decrease natural resources of soil fertility (Kremer and Li, 2003). Press-mud is a minor, light, nebulous and unclear cocoa to earthy white imperative, holding sugar, coagulated colloids involving aluminous, cane wax, mineral salts, fiber and various components of soil (Satisha *et al*. 2007). Press-mud help in reclaiming the sodic and saline-sodic soils moreover, it utilized as soil manures which improve soil supplements as well as availability and solubility (Barry *et al.*, 2001). Press-mud is comprised of nitrogen, phosphorus, potash and basic nutrients and it has improved the soil physical and chemical properties (Rangaraj *et al.*, 2007). The higher amount of nitrogen, phosphorus and potassium in press-mud has finished the value of nutrients strength (Rakkiyappan *et al.*, 2001).

Unfavorable weather elements, for instance, low rainfall, meager soil nourishment, high solar radiation in the dry spell, water logging, low temperatures and saline soils stunt growth, development and yield of cane to more a greater extent (Enyard *et al*., 2005). Under dry and arid conditions, cane development retards not just because of the evapotranspiration in cane fields but also due to the shortage of water supply as medium for take-up of the supplements from soil, as a reactant in plant metabolic process and last however not the minimum in translocation of photo-assimilates in plants (Taiz and Zeiger, 2010; Joab Onyango Wamari, 2019). At certain growth and phonological stages, the slow releasing fertilizers are getting fame as those ensure supply of nitrogen for a longer period to soil hence proved successful in gathering plant necessities (Nash *et al*., 2103). Macro and micro nutrients are important to fulfill the growth and development of sugarcane to improve the source sink association and enhance sugarcane yields by getting a more biomass an inference of its C_4 (Fageria *et al*., 2009). Polymers are safe to use with non-destructive nature, easily soluble having dissolvable base and potassium parts with no releasing up (Martin, 1997). To facilitate undesirable fertilizers sickness from the topsoil, use of super absorbent polymer (SAP) in the field of agronomy could be a suitable absorber of water contents and manure nutrients closefisted developed for semi-arid regions of Northern China and exceptionally dry zones. In addition, the polymers coated supplement can handle on soil manure and compost up to five years along these applications (Martin, 1997). Shao *et al.*, (2007) depicted that hydrophilic polymers helped in retention of soil water sensible to plant roots by discouraging salt concentration levels. In this way use of polymers also limit the exchange of K^+ and Ca^{2+} through buffering action.

Investigation for recognizable proof of better agronomic management as far as appropriate cane nutrition especially under water scarce conditions has turned out to be unavoidable for country like Pakistan because of geopolitical reasons and expected letdown of Indus Basin Treaty. Hence, planned study was target:

- To evaluate the yield response of sugarcane ratoon to natural and synthetic soil supplements / composts under water scarcity
- To assess the best combination of soil amendment and different irrigation regimes to improve the development and yield of sugarcane ratoon.

MATERIALS AND METHODS

An experiment was conducted on directorate farm of University of Agriculture Faisalabad during 2016-17 to estimate the impacts of soil amendments practices on growth and yield attributes of spring planted sugarcane (Saccharum Officinarum L.) under water deficit conditions. The soil analysis was done before sowing of the sugarcane crop. Soil of the Faisalabad region is irrigated by canal water, formed by the material carried by Ravi and Chenab water have alluvial texture. Experimental site is located at the altitude of 150 m above sea level.

Analysis of experimental soil

Soil sampling was done from different places up to a depth of 30 cm before sowing of crop and physio-chemical analysis was made during 2017. The results about physio-chemical analysis of the experimental soil are presented in Table 1. The analysis of soil expose that the field trial site was slightly alkaline and loam soil. However, the experimental area, selected for crop husbandry was deficient in major primary nutrients NPK (nitrogen, phosphorus and potash).

Meteorological information of research station

Data regarding meteorological parameters was collected from the Agricultural. Meteorology Cell, University of Agriculture, Faisalabad, Pakistan to observe the ecological factors and recordings are given in figure 1. Total rainfall during the period of March 2017 to February 2018 was 330.27 mm.

Experimental Design and Treatments

A field trial was done in Randomized Complete Block Design (RCBD) under split plot arrangements having three replications. The net plot sizes were 10.00 m × 6.0 m with 5 rows.

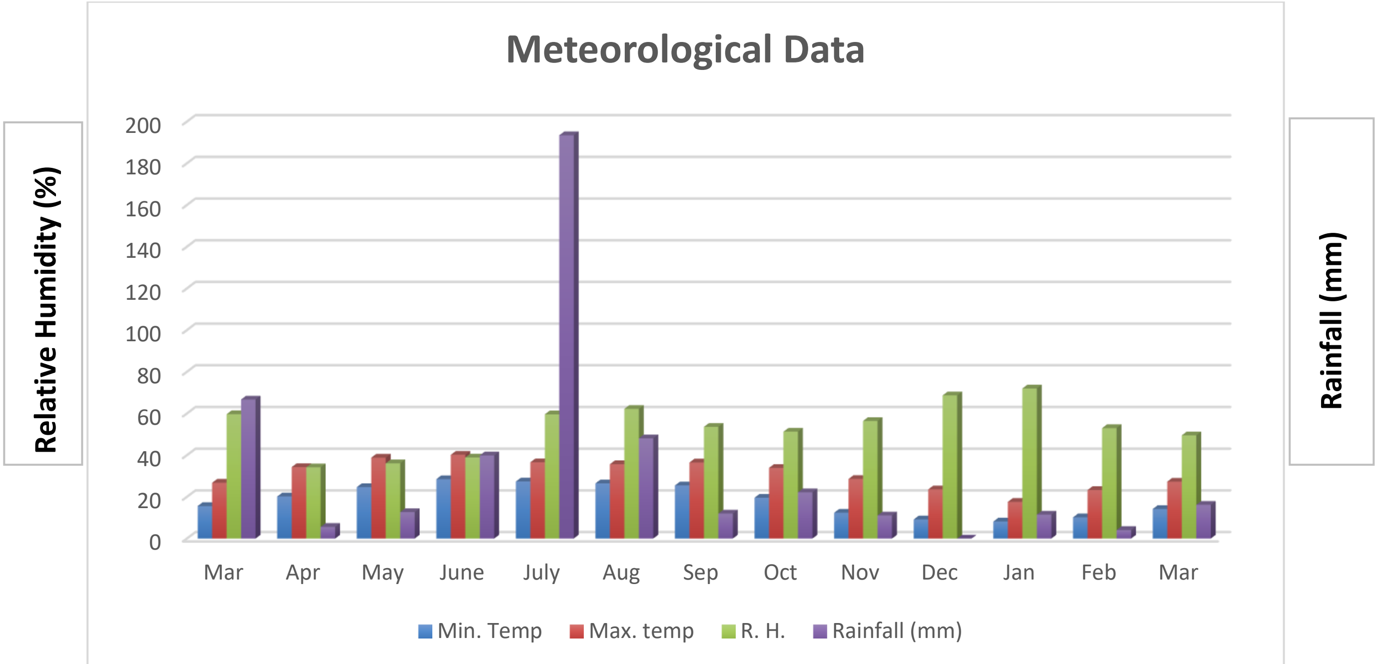

Figure 1 Meteorological data during the growth season of the cane crop (Mar-2017 - Mar-2018)

Treatments

Factor A. Irrigation Scheduling

I_0 =100% of Recommended Irrigation (16 Irrigations), I_1 =75% of Recommended Irrigation (12 Irrigations). I_2 =50% of Recommended Irrigation (08 Irrigations).

Factor B. Organic and Coated Fertilizer

T_0 = Control, T_1 =Press-mud (obtained from sugar mills), T_2 = Polymer Coated Single Super Phosphate (SSP), T_3 = 50% Cane Trash boiler ash + 50 % Sulphate of Potash (SOP).

Crop husbandry

Preparation of seed bed

The experimental soil was prepared well by deep ploughing through disk and well-rotted farmyard manure (FYM) was applied to increase the efficiency of soil. Moreover, all the optional doses of press mud, bio organic phosphorus, and polymer coated SSP and chopped cane leaves with artificial fertilizer with the ratio of 50:50 percent respectively applied at the time of sowing.

Sowing of Crop

Sugarcane ratoon crop with variety CPF-249 was selected for experimental purpose. However, crop was planted during mid of March 2016 and harvested during 15th February, 2017 and kept as a ratoon crop for the next year. During next year 2018, ratoon crop of sugarcane was harvested at 20th of February and data regarding parameters were recorded from that crop.

Fertilization and Earthing up

Synthetic fertilizer, integrated with organic amendments were applied @ 168 kg/ha of nitrogen, 112 kg/ha of P_2O_5, and 112 kg/ha of K_2O. However, resources for synthetic fertilizers include urea, SOP and K_2O and for organic based fertilizers these were bioorganic phosphorus, polymer coated SSP, chopped cane leaves and press mud. At the time of sowing all recommended dose of synthetic fertilizers including phosphorous and potash and 1/3rd of nitrogen were applied as a basal dosage and broadcasted. However, remaining amount of nitrogen was used to crop in two splits, 1/3rd at initial stage of tillering. Moreover, after 90 days of germination earthing-up of sugarcane was done.

Harvesting of Crop

At physiological maturity the harvesting was done manually on 18th Feb. 2018.

Recording Observations

Data pertaining to the subsequent parameters were measured by applying standard procedures during the course of study. Following observations were recorded like Number of tillers per m^2, number of millable canes m^{-2}, cane length (cm), number of internodes per cane, cane internodal length (cm), cane diameter (cm), Stripped cane yield (tons ha^{-1}), unstripped cane yield (tons ha^{-1}), cane tops weight (tons ha^{-1}), harvest index (%), brix (%), Pol. (%), commercial cane sugar (%), cane sugar recovery (%).

RESULTS AND DISCUSSION

The trial was executed to study, the influence of various soil amendments to improving the growth, yield and quality parameters as well as WUE of spring sown sugarcane (Saccharum officinarum L.). Water use efficiency and sustainable application of nutrients are very significant factors influencing growth and development of sugarcane, especially spring planted. Inappropriate use of irrigation water and fertilizer amendments are the unbeatable problems, reducing per hectare yield of sugarcane. The study was directed to check the impacts of different irrigation levels along with fertilizer managing practices. Data were collected on Number of tillers per plant, Number of millable canes per m^2 at harvest, Cane length (cm), Number of internodes per cane, Length of internodes (cm), Cane girth (cm), Stripped cane weight (kg), Stripped cane yield (t ha^{-1}), Un-stripped cane yield (t ha^{-1}), Total sugar

yield (t ha^{-1}), Tops weight (t ha^{-1}), Harvest index (%),Trash weight (t ha^{-1}), Pol. (%), Brix (%), Fiber (%), Commercial cane sugar (%), Cane sugar recovery (%) and Cane juice purity (%) and analyzed statistically and interpreted.

Number of tillers per plant

Tillering is considered as a significant yield parameter of sugarcane crop and plays a major role in the final yield of cane. The data given (table-2) showed that irrigation level had highly/significant effect on the number of/tillers per single plant. The more number of tillers per single plant (14.32) were obtained in I_0 (100% recommended irrigation 16 irrigations) against the minimum number of tillers per plant (11.63) at I_2 (50% of recommended irrigation 8 irrigations). While the number of tillers per plant increasing by soil applied amendments the all-out number of tillers (14.21) was gathered in T_2 (polymer coated SSP). The significant outcome of treatments for tillers per plant was maybe due to genetic potential of variety or availability of moisture in sufficient amount needed for tillering. However, combined effects of both factors and alone results of fertilizer application were non-significant for tillers per plant.

Number of millable canes

Number of millable canes is another most significant component of sugarcane yield character, which is the result of number of sprouts per square meter and germination percentage. Analysis of variance in Table 3 revealed that irrigation level has significant effect on the number of millable canes. Statistically, the highest number of millable canes (13.64 m^{-2}) were recorded in I_0 (100% of recommended irrigation) that was statistically at par with I_1 (75% of recommended irrigation) having number of millable canes per meter square (13.18 m^{-2}) that at par with I_2 (50% of recommended irrigation) having the (10.43 m^{-2}) number of millable canes. However, combined effect and fertilizer application alone were observed to be non-significant. The more number (14.07 m^{-2}) of millable canes were gathered in T_2 and the lowest number of millable canes (11.73 m^{-2}) were observed in T_0 (control). The number of millable cane was ranged between 10.0 and 15.33 per m^2 in the interactive effect of irrigation level and soil amendments. The better number of millable canes in I_0 (100% of recommended irrigation) might be due to the better soil moisture content, light penetration and circulation of air. However, a little decrease was observed in I_2 (50% of recommended irrigation) this decrease might be due to less moisture content and sprouting of lateral shoots which produced more non-millable canes and caused substantial reduction in millable canes.

Cane length (cm)

Length of can stalk is a significant quantitative yield component that is positively associated with stripped cane yield of sugarcane. Data regarding the cane length are presented in Table 4. Results showed that levels of irrigation and kinds of fertilizer markedly affected the cane length. Statistically significant highest cane length (206.58 cm) was recorded in I_0 (100% of recommended irrigation) followed by cane length (194.83 cm) was recorded in the I_1 (75% of recommended irrigation) while the minimum cane length (176.75 cm) was recorded in I_2 (50% of recommended irrigation). On the other hand, the fertilizer effects the maximum cane length (206.9 cm) was observed in the T_2 (polymer coated SSP) that statistically at par with T_3 (50% Cane Trash boiler ash+50% SOP), T_1 (Press-mud) and T_0(control) having the cane length (176.6 cm) which is statistically significant than other treatments. The interactive effect of irrigation and fertilizer was non-significant on the cane length.

Number of internodes per cane

The no. of internodes/cane which affects the final yield of sugarcane is genetic character of variety, also represent the development of cane. A significant ($P \leq 0.05$) effect of irrigation levels and fertilizers was recorded on internodes per cane of sugarcane as displayed in Table 5. While the data revealed that the maximum number of internodes (16.3) was observed in I_0 (100% of recommended irrigation level) against the I_2 (50% of recommended irrigation) had the (10.9) number of internodes per plant. While, maximum number of internodes (14.2) was observed in T_2 (polymer coated SSP) statistically similar with T_0 (control), T_2 (press-mud) and T_3 (50% cane trash boiler ash+50% SOP). Whereas, interactive effect of irrigation and fertilizers was non-significant.

Length of internodes

The intermodal length of cane along with the number of internodes per plant have a major share in final yield of cane crop. Data representing the intermodal length of cane are given in the Table 6. Showing that the irrigation and fertilizer has highly significant effect on internodal length. The maximum intermodal length was recorded (14.27 cm) in the I_0 (100% of recommended irrigation) statistically differed from all other treatments. While, minimum length (8.83 cm) of internodes observed in the I_2 (50% of recommended irrigation). The soil amendments have highly significant effect on the intermodal length in which T_2 (polymer coated SSP) gave maximum internode length (13.4 cm) which statistically different from other treatments. The minimum value (10.5 cm) was recorded in the plots treated with T_0 (Control). However, the combined effect of level of irrigation and soil amendments had non-significant effects on the intermodal length.

Stripped cane yield (tons per ha)

The yield of stripped cane is influenced by many factors i.e. total cane stalk per unit area, weight of stripped cane, cane length, millable canes at maturity and cane width. The final yield of sugarcane is a role of the interactive effects of different yield characters. Treatment means given in Table 7 exhibited that irrigation regimes and soil amendments considerably affected the stripped cane yield. The irrigation level has highly significant effects on the stripped cane yield. The highest stripped cane yield (47.67 t/ha) was recorded in the I_0 (100% of recommended irrigation) however, statistically differed from all irrigation levels. Lower stripped cane yield (24.12 t/ha) was recorded in I_2. On the other hand, effects of soil amendment treatments were also statistically significant as maximum stripped cane yield (40.89 t/ha) was recorded in T_2 (polymer coated SSP) and the lowest stripped cane yield (37.29 t/ha) was gathered in T_0 (control). Difference in stripped cane yield in irrigation levels and soil amendments might be ascribed to availability of nutrients and moisture content at growth and development stages of sugarcane. The interactive effect of different levels of irrigation and soil applied amendments on the stripped cane yield was recorded statistically non-significant.

Unstripped cane yield (tons/ha)

The information of total biomass produced of un-stripped cane (tons/ha) of a sugarcane crop giving in the table 8 showed that this component of sugarcane was highly significant affected by different levels of irrigation and soil amendments application. Significantly maximum (66.25 tons/ha) un-stripped cane yield of cane was observed in I_0 (100% of

Table 1 Physio-Chemical soil examination of the experimental site

A.	Physical Analysis.	
Parameter	Values	Units
Clay	27.6	%
Sand	32.4	%
Silt	40.0	%
Textural Class	Loam	
B.	Chemical Analysis.	
EC	1.47	dS m^{-1}
pH	7.91	--
Organic matter (OM)	1.06	%
Total nitrogen	0.043	%
Accessible phosphorous.	8.07	ppm
Available potassium.	260	ppm

Table 2 Analysis of Variance and effect of different irrigation level and soil applied amendments on no. tillers m^{-2} of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	0.38	0.19	
Irrigation (IR)	2	45.88	22.94	24.75**
Error Rep*IR	4	3.71	0.93	
Fertilizer (FR)	3	13.98	4.66	2.36NS
IR*FR	6	2.36	0.39	0.20NS
Error Rep*IR*FR	18	35.54	1.97	
Total	35	101.85		

DF = Degree of Freedom **SS = Sum of square** **MS = Mean sum of square**
NS = Non-significant **** = Highly Significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	14.00	13.67	15.63	14.00	14.32 A
I_1	13.00	13.46	14.00	13.50	13.50 A
I_2	11.00	11.13	13.00	11.37	11.63 B
Mean	12.67	12.76	14.21	12.96	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 1.40 **HSD** value for FR = 1.87

Means not sharing the common letter vary significantly at 5% probability level.

Table 3 Analysis of Variance and effect of different irrigation level and soil applied amendments on No. of millable canes per meter square of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	1.55	0.78	
Irrigation (IR)	2	72.66	36.33	35.39**
Error Rep*IR	4	4.10	1.03	
Fertilizer (FR)	3	32.99	10.99	8.53**
IR*FR	6	2.14	0.36	0.28NS
Error Rep*IR*FR	18	23.21	1.29	
Total	35	136.67		

DF = Degree of Freedom **SS = Sum of square** **MS = Mean sum of square**
NS = Non-significant **** = Highly Significant**

B. Contrast of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	12.93	13.03	15.33	13.27	13.64 A
I_1	12.27	12.67	14.80	13.00	13.18 A
I_2	10.00	10.30	12.07	9.33	10.43 B
Mean	11.73 B	12.00 B	14.07 A	11.87 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 1.47 **HSD** value for FR = 1.51

Means not sharing the common letter vary significantly at 5% probability level.

Table 4 Analysis of Variance and effect of different irrigation level and soil applied amendments on cane length (cm) of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	18.7	9.36	
Irrigation (IR)	2	5420.4	2710.19	598.57**
Error Rep*IR	4	18.1	4.53	
Fertilizer (FR)	3	4240.3	1413.44	52.80**
IR*FR	6	123.8	20.64	0.77NS
Error Rep*IR*FR	18	481.8	26.78	
Total	35	10303.2		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square **** = Highly Significant** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	193.0	205.3	220.0	208.0	206.58 A
I_1	180.0	192.0	210.3	197.0	194.83 B
I_2	157.0	176.68	190.3	183.0	176.75 C
Mean	176.67 C	191.33 B	206.90 A	196.00 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 3.09 **HSD** value for FR = 6.8

Means not sharing the common letter vary significantly at 5% probability level.

Table 5 Analysis of Variance and effect of different irrigation level and soil applied amendments on Number of internodes per plant of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	6.49	3.25	
Irrigation (IR)	2	177.3	88.66	109.92**
Error Rep*IR	4	3.23	0.81	
Fertilizer (FR)	3	27.02	9.01	10.99**
IR*FR	6	1.10	0.18	0.22NS
Error Rep*IR*FR	18	14.74	0.82	
Total	35	229.89		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square **** =Highly Significant** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	15.5	15.4	17.7	16.6	16.3 A
I_1	13.2	13.6	15.6	14.8	14.3 B
I_2	10.3	10.4	12.0	11.0	10.9 C
Mean	13.0 B	13.1 B	14.2 A	14.1 AB	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR =1.30 **HSD** value for FR = 1.21

Means not sharing the common letter vary significantly at 5% probability level.

Table 6 Analysis of Variance and effect of different irrigation level and soil applied amendments on internode length (cm) of sugarcane
A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	3.1	1.5	
Irrigation (IR)	2	188.9	94.5	100.6**
Error Rep*IR	4	3.8	0.9	
Fertilizer (FR)	3	40.5	13.5	34.81**
IR*FR	6	2.4	0.4	1.02NS
Error Rep*IR*FR	18	6.9	0.4	
Total	35	245.6		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square *** = Significant at 5% probability** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	13.2	13.9	16.0	14.1	14.27 A
I_1	11.4	12.3	14.0	13.3	12.74 B
I_2	7.0	8.7	10.3	9.3	8.83 C
Mean	10.5 C	11.6 B	13.4 A	12.2 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR =1.41 **HSD** value for FR = 0.83

Means not sharing the common letter vary significantly at 5% probability level.

Table 7 Analysis of Variance and effect of different irrigation level and soil applied amendments on stripped cane yield (t ha^{-1}) of sugarcane
A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	1.27	0.63	
Irrigation (IR)	2	3840.47	1920.23	793.92**
Error Rep*IR	4	9.67	2.42	
Fertilizer (FR)	3	68.94	22.98	50.68**
IR*FR	6	3.70	0.62	1.36NS
Error Rep*IR*FR	18	8.16	0.45	
Total	35	3932.21		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square *** *= Highly Significant** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	46.17	47.43	50.13	46.93	47.67 A
I_1	42.70	43.00	46.47	43.52	43.92 B
I_2	23.00	23.03	26.07	24.4	24.12 C
Mean	37.29 C	37.82 BC	40.89 A	38.28 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 2.26 **HSD** value for FR = 0.897

Means not sharing the common letter vary significantly at 5% probability level.

Table 8 Analysis of Variance and effect of different irrigation level and soil applied amendments on unstripped cane yield (tons/ha) of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	3.65	1.83	
Irrigation (IR)	2	3001.32	1500.66	9630.94**
Error Rep*IR	4	0.62	0.16	
Fertilizer (FR)	3	70.17	23.39	25.27**
IR*FR	6	5.09	0.85	0.92NS
Error Rep*IR*FR	18	16.66	0.93	
Total	35	3097.53		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square *** *= Highly Significant** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	65.07	65.20	68.73	66.00	66.25 A
I_1	62.27	62.42	64.93	62.70	63.08 B
I_2	43.27	45.00	48.03	45.67	45.49 C
Mean	56.87 B	57.54 B	60.57 A	58.12 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 0.57 **HSD** value for FR = 1.28

Means not sharing the common letter vary significantly at 5% probability level.

Table 9 Analysis of Variance and effect of different irrigation level and soil applied amendments on harvest index % of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	17.80	8.9	
Irrigation (IR)	2	2653.57	1326.78	465.66**
Error Rep*IR	4	11.40	2.85	
Fertilizer (FR)	3	68.14	22.71	10.85**
IR*FR	6	8.20	1.37	0.65NS
Error Rep*IR*FR	18	37.68	2.09	
Total	35	2796.77		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square *** *= Highly Significant** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	70.01	71.97	74.33	70.69	71.75 A
I_1	68.58	68.89	72.17	69.40	69.76 A
I_2	51.94	51.23	54.64	52.69	52.62 B
Mean	63.51 B	64.03 B	67.05 A	64.26 B	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR: 2.457 **HSD** value for FR: 1.93

Means not sharing the common letter vary significantly at 5% probability level.

Table 10 Analysis of Variance and effect of different irrigation level and soil applied amendments on brix (%) of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	1.37	0.68	
Irrigation (IR)	2	0.66	0.33	0.47NS
Error Rep*IR	4	2.80	0.70	
Fertilizer (FR)	3	41.59	13.86	10.49**
IR*FR	6	1.10	0.18	0.14NS
Error Rep*IR*FR	18	23.78	1.32	
Total	35	71.30		

SOV = Source of Variance
DF = Degree of Freedom
SS = Sum of square
MS = Mean sum of square
*** *= Highly Significant**
NS = Non-significant

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	18.80	19.20	21.67	20.92	20.15
I_1	18.97	19.40	21.58	20.40	20.08
I_2	18.50	19.40	21.43	20.00	19.83
Mean	18.76 C	19.33 BC	21.56 A	20.44 AB	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for FR: 1.53

Means not sharing the common letter vary significantly at 5% probability level.

Table 11 Analysis of Variance and effect of different irrigation level and soil applied amendments on pol (%) of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	2.48	1.24	
Irrigation (IR)	2	2.50	1.25	3.31NS
Error Rep*IR	4	1.51	0.38	
Fertilizer (FR)	3	4.93	1.64	2.33NS
IR*FR	6	3.01	0.50	0.71NS
Error Rep*IR*FR	18	12.71	0.71	
Total	35	27.13		

SOV = Source of Variance
DF = Degree of Freedom
SS = Sum of square
MS = Mean sum of square
NS = Non-significant

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	18.83	19.63	19.19	18.58	19.06
I_1	18.63	19.33	19.23	17.55	18.69
I_2	18.37	18.53	18.37	18.40	18.42
Mean	18.61	19.17	18.93	18.18	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

Means not sharing the common letter vary significantly at 5% probability level.

Table 12 Analysis of Variance and effect of different irrigation level and soil applied amendments on commercial cane sugar percentage of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	0.23	0.12	
Irrigation (IR)	2	0.03	0.02	0.13NS
Error Rep*IR	4	0.52	0.13	
Fertilizer (FR)	3	0.47	0.16	1.82NS
IR*FR	6	0.23	0.04	0.45NS
Error Rep*IR*FR	18	1.54	0.09	
Total	35	3.03		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	14.85	14.88	15.00	15.02	14.94
I_1	14.70	15.00	15.10	14.82	14.91
I_2	14.65	14.75	15.02	15.04	14.87
Mean	14.73	14.88	15.04	14.96	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

Means not sharing the common letter vary significantly at 5% probability level.

Table 13 Analysis of Variance and effect of different irrigation level and soil applied amendments on cane sugar recovery % of sugarcane

A. Analysis of Variance

SOV	DF	SS	MS	F
Replication	2	0.03	0.02	
Irrigation (IR)	2	1.62	0.81	16.47*
Error Rep*IR	4	0.20	0.05	
Fertilizer (FR)	3	0.27	0.09	1.98NS
IR*FR	6	0.09	0.02	0.34NS
Error Rep*IR*FR	18	0.18	0.05	
Total	35	3.03		

SOV = Source of Variance **DF = Degree of Freedom** **SS = Sum of square**
MS = Mean sum of square *** = Significant at 5% probability** **NS = Non-significant**

B. Comparison of treatment means

Number of irrigations	Organic and Synthetic Supplements				Mean
	T_0	T_1	T_2	T_3	
I_0	14.47	14.20	14.53	14.42	14.40 A

I_1	14.44	14.20	14.52	14.36	14.38 A
I_2	13.92	13.96	13.96	13.92	13.93 B
Mean	14.29	14.10	14.34	14.23	

T_0 = Control
T_1 = Press-mud
T_2 = Polymer Coated SSP
T_3 = 50% Cane Trash boiler ash+50% SOP

I_0 = 100% of REC. Irrigation (16 Irrigations)
I_1 = 75% of REC. Irrigation (12 Irrigations)
I_2 = 50% of REC. Irrigation (8 Irrigations)

HSD value for IR = 0.32

Means not sharing the common letter vary significantly at 5% probability level.

recommended irrigation) than the I_2 (50% of recommended irrigation) having 45.49 tons/ha un-stripped cane yield. The impacts of soil amendments application on the yield of un-stripped cane was also found statistically highly significant. Observations regarding un-stripped yield as affected by different types of soil amendments application in the soil showed that there was statistically highly significant difference for unstripped cane yield between the treatment means. The highest unstripped cane yield (60.57 tons/ha) was recorded in T_2 (polymer coated SSP) that is statistically different from all other treatments. The interactive influence of irrigation levels and soil amendments application was recorded non-significant.

Harvest index

Harvest index is expressed in percentage and defined as the ratio of commercial yield to total biomass yield. The harvest index of the sugarcane crop as affected by different irrigation levels statistically showed (table 9) the significant effect on the harvest index of the sugarcane. The crop plant having I_0 (100% of recommended irrigation) gave maximum harvest index (71.75%), statistically significant with I_1 (75% of recommended irrigation).The effect of soil amendments application was also statistically significant and its range was from 63.51% in T_0 (control) to 67.05% in T_2 (polymer coated SSP) application. The combined influence of levels of irrigation and soil amendments application was also recorded statistically non-significant.

Brix percentage

The total amount of solutes absorbed in a cane juice (a natural solution) is defined as the ‘brix degree’ and expressed in percentage. Brix degree of cane juice is an important component to represent the maturity of cane. Data presented in Table 10 revealed that irrigation levels had not significantly affected the brix (%) of cane. Although brix percentage in cane juice was different in cane grown at various irrigation levels but this difference could not have reached to the level of significance and it ranged between 20.15% and 19.83% recorded in I_1 (12 irrigations) and I_2(08 irrigations), respectively. The soil amendments effect on the brix percentage was statistically significant and its ranges the maximum brix percentage value (21.56%) found in the T_2 (polymer coated SSP) and the minimum value recorded at T_0 (control) having (18.76%) of cane brix percentage. While the interactive effect of irrigation and different fertilizers has also non-significant on brix percentage of all treatment means.

Sucrose content in juice (%)

Gross carbohydrate i.e. pol % (total sugars of all classes in the cane juice) is another most important quality yield-determining factor and usually precise by genetic make-up of a variety and conservational conditions under which the cane crop grown. Treatment means revealed a non-significant effect of various irrigation levels on sucrose contents. However, the sucrose contents ranged between 19.06% and 18.42%. The soil amendments have also affect statistically non-significant on the sucrose content in the juice %, the maximum value recorded in 19.17% in the T_1 (control) against the lowest value found in T_3 (cane trash boiler ash + 50% SOP) having 18.18% sucrose content in cane juice. While the interactive effects of irrigation and soil amendments remain also non-significant on the pol %.

CCS (%)

The actual sugarcane quality is represented by its (CCS %) commercial cane sugar. Commercial cane sugar (CCS %) is the finishing goal to attain maximum sugar produce. It is mainly well-ordered by genetic make-up of a variety and ecological conditions prevailing during the growth and development of sugarcane crop. Commercial cane sugar was no significantly affected by different irrigation levels and soil amendments. However, it is clear from Table 12 which showed that the maximum value of commercial cane sugar (14.94%) and (15.04%) was found in I_0 (16 irrigations) and T_2 (polymer coated SSP).Whereas, the soil amendments and its interactive effects with irrigation levels was also non-significant on commercial cane sugar, the maximum cane sugar recorded (15.10%) in I_1T_2 (75% of recommended irrigation + polymer coated SSP) and the minimum commercial cane sugar (14.65%) was observed in I_2T_0 (50% of recommended irrigation + control).

Cane sugar recovery (%)

Cane sugar recovery is an important quality index of cane components which depends upon many factors like plant genetic make-up, environmental situations, and the instrument used for the cane sugar recovery percentage. Data regarding the sugar recovery given in Table 13 indicates that different irrigation levels had significant effect on sugar recovery in cane grown under different soil amendments treatments. Cane sugar recovery effects statistically equally in I_0 (100% of recommended irrigation) and I_1 (75% of recommended irrigation) that giving the values of (14.40 %) and (14.38 %) respectively. But statistically differed cane sugar recovery percent (13.93%) was gathered in I_2 (50% of recommended irrigations). However, the soil amendments and its shared effects has non-significant on the cane sugar recovery that’s ranges between the values of 13.92 % to 14.53%.

CONCLUSION

It was concluded that the best combination treatment (I_0T_2) where 100% of recommended irrigation was applied with polymer coated SSP fertilizer is proved to be the most economical than the others for sugarcane ratoon production.

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